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Pedestrian Safety: Microscopic Analysis of Pedestrian Risk Exposure

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I. PROBLEM STATEMENT

"An assessment of safety related risks to which the pedestrians are exposed and factors affecting risk exposure"

The present study makes an insight in the domain of pedestrian Risk Exposure and reviews the efforts of various studies conducted to analyze the risk exposure of pedestrians using Microscopic analysis. Microscopic analysis presents a more realistic picture by examining and predicting risk exposure among pedestrians as compared to the conventional macroscopic analysis techniques which involve holistic parameters like Number of road crashes or casualties, walking distance travelled, walking time spent, number of trips, number of road crossings etc.

In contrary, Microscopic analysis encompasses the pedestrian characteristics while including the road and traffic characteristics. It also includes minute, yet indispensable aspect of pedestrian‟s compliance to traffic rules. The study is more relevant in Indian context wherein a spate of roadside crashes is witnessed on a daily basis, particularly during pedestrian crossing events. The domain proposed earlier was "Factors affecting Pedestrian Safety". A thorough introspection into the domain unraveled that the *analysis of risk exposure of pedestrians* has gone a long way towards effective assessment of pedestrian-vehicular crashes , while also emboldening authorities to make necessary interventions towards mitigating the risk posed to the safety of pedestrians. In this context, a myriad of methodologies and techniques have come to fore, however, recent studies have focused more towards Microscopic analysis of risk exposure. A brief insight into such techniques including PV analysis, Survival analysis, Sequential logit model and multiple linear regression models shall be made in the succeeding heading.

II. SUMMARY OF PAPERS READ

A. *Type of Study*

The various studies encompass pedestrian risk exposure and rely on observing *pedestrian- vehicular interaction and pedestrian behavior* which have a direct impact on risk exposure. Study conducted by Meriem Mandar[5] is an exposure study which *simulates* exposure.

B. *Types of Dependent Variable Used*

1) The Survival analysis technique employed by G.Tiwari(2007) [1] , determines pedestrian risk by taking *„probability of survival(KM probability)"* as a dependent variable. In this context, a myriad of independent variables affect this probability which in turn gives a measure of risk and exposure.
2) A thorough study conducted by Cameron(1981) [2] defines *risk and exposure* based on number of parameters.
3) Eleonora and Yannis(2012)[3] employed "crossing probability" as a dependent variable.
4) Xiao Qin and John N. Ivan[4] used "*log of weekly pedestrian exposure"* as a dependent variable in their multiple linear regression model.
5) Meriem Mandar[5] predicted "pedestrian exposure" by using fuzzy model and cellular automata technique.

C. *Types of safety-related traits Described, and the Nature of their Relationship*

A plethora of safety related traits were incorporated in the aforementioned studies . The various traits/parameters employed include:

1) G.Tiwari(2007) examined *number of waiting pedestrians, number of pedestrians at risk, waiting times, Age, Arrival and departure times, and gender of pedestrians* in his study. In order to gauge the overall impact on *„probability of survival",* across different crossing conditions and road characteristics, the study was conducted on different *road geometries(4 arm and 3-arm intersections)* and also checked for presence of sidewalks.
2) Cameron(1981) in his study derived risk and exposure by PV analysis(product of pedestrian and traffic volume). Subsequently, accident risk was computed by taking the average of pedestrian accidents and (PV).

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3) Eleonora and Yannis(2012) considered a myriad of safety related aspects pertaining to Road geometry and traffic characteristics which included *Cumulative trip length, Presence/Absence of traffic signals, number of lanes, lane width, Traffic volume* .
4) Xiao Qin and John N. Ivan in their multiple linear regression model to access "weekly pedestrian exposure" considered various parameters including *Pedestrian Ameneties(Sidewalks), Traffic Control(marked crosswalk and presence/absence of traffic signal), Demographic data (Household income), Land Use Characteristics(Commercial , residential or institutional area), Road Site features(number of lanes, road width etc).*All these parameters profoundly impact the risk exposure of pedestrians.Traffic control embolden pedestrians to cross the road stretch safely. Similarly, the risk exposure in tourist areas and commercial areas will be totally different due to travel patterns of pedestrians , apart from the high congestion of traffic in commercial areas. Road Side features also have a pronounced impact on risk exposure, since the length of the road to which the pedestrian feels exposed increases with the increase in lane width.
5) Meriem Mandar[5] considered the impact of *speed, density and waiting times of pedestrians and crossing times* while formulating pedestrian exposure.

D. Types of Statistical Techniques Used

Different methodologies have been employed by the studies mentioned here-to-fore. A brief outline of the techniques used is as follows:

1) G.Tiwari(2007) used *Discrete Time Survival Analysis* as a tool to formulate Pedestrian Risk Exposure. This methodology used in the present context is based on the premise that a crossing is unsafe for pedestrians when the traffic signal turns Yellow or Green. An„event" is considered as a „risk" if the pedestrian crosses the road during this period. The technique used is Kaplan – Meier(KM) survival curve(a plot between KM survivor function and time) which in turn gives us the probability that a pedestrian would initiate an unsafe crossing.
2) Cameron(1981) used *PV analysis* wherein he defined exposure as the product of the number of pedestrians and vehicles. He subsequently used concepts of probability to arrive at "accidental risk", which was the conditional expectation of N number of crashes given E potential accidents occur.
3) Eleonora and Yannis(2012) employed *Sequential logit model* with three alternatives: crossing at midblocks, crossing at junction and no crossing.
4) Xiao Qin and John N. Ivan conformed to *Multiple linear regression* technique in order to model the weekly pedestrian exposure with respect to various independent variables.
5) Meriem Mandar used *Fuzzy ant model approach* for simulating the risk exposure of pedestrians. This technique is gets its name from the pheromone laying trail of ants wherein the shortest possible path is chosen. The model is based on the concept of *cellular automata*. Subsequently, simulation is performed.

III. KEY SAFETY-RELATED FINDINGS

The key findings from the aforementioned studies can be summarized as follows; Pedestrian risk exposure is dependent on a myriad of various parameters including road geometrics, demographic factors, pedestrian behavior and traffic characteristics. Xiao Qin and John N. Ivan in their study using linear regression arrived at various conclusions. The provision for sidewalks mitigated the risk exposure of pedestrians. Similarly, a 2- lane road witnesses a higher risk exposure as compared to a 4-lane highway. Effect of land use on exposure is also predominant. It was concluded that Institutional areas had greatest exposure for risks than tourist areas. As a result such areas need more consideration by authorities in terms of roadside facilities.

Study conducted by G.Tiwari(2007) concluded that as the pedestrian waiting time increases, pedestrians get impatient and therefore violate traffic signals .As a result , they conform to the practice of crossing the road while the green and yellow traffic lights for vehicular traffic is still in operation. Therefore, the risk increases. Reducing the waiting time thus decreases the probability of pedestrians being hit by a vehicle. Furthermore, all road users (vehicular and pedestrian traffic) share a common carriageway which is primarily due to inadequate pedestrian facilities. This in-turn increases the overall risk posed to pedestrians. It was also concluded that as pedestrian delay increases m the survival time also increases. Correlation between pedestrian delays and People doing unsafe crossing(%) was positively correlated(Corr. =0.63), which suggested that as delays increases, the pedestrians tend to conform to unsafe road crossings. Eleonora and Yannis(2012) concluded that pedestrian exposure is directly related to traffic speed and density. It was concluded that pedestrians with low walking speeds are most exposed due to increased time of interaction with vehicles. The highest exposure corresponded to [low walking speed and high volume] .

IV. A COMPARISON WITH THE SYNOPSIS HYPOTHESIS:

1) As predicted , higher speeds of vehicles tend to increase the risk of pedestrians.
2) Longer the waiting time for pedestrians to cross a road, more is the likeability of indiscriminate crossing, thus posing safety risks. This was attested by G.Tiwari(2007).
3) Children are more prone to risks as compared to old people. Women are less exposed to risks than men.

V. MODIFICATIONS TO BE INCORPORATED WHILE ASSESSING PEDESTRIAN RISK EXPOSURE IN INDIAN CONTEXT

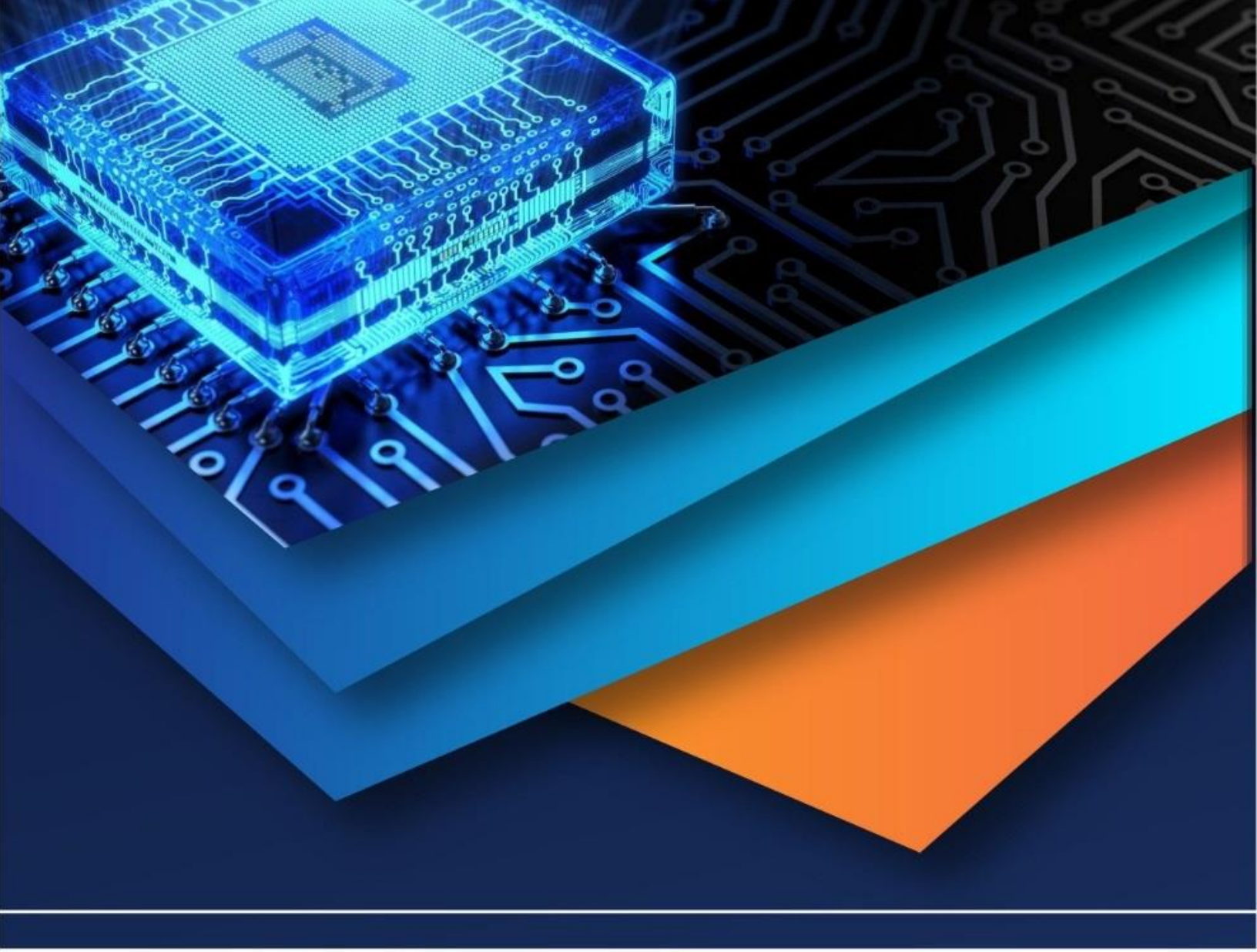
Indian traffic scenario is distinct due to heterogeneous mixed traffic conditions. In this context, a spate of changes needs to be incorporated while pursuing the assessment of risk exposure in India. Some of these would include:

1) Due to mixed traffic conditions, considering the effect of speed variation of traffic on pedestrian behavior and risk associated becomes imperative.
2) Effect of on-street parked vehicles and obstructions like street vendors needs to be considered because they considerably tend to reduce the carriageway width .Besides, pedestrians who tend to cross the road in presence of a side-parked vehicle is more prone to risks due to being out of sight for the incoming vehicle on road.
3) The effect of walking in groups or alone should be considered.
4) The kerb height of sidewalks and medians is considerably high in India, which is practically inaccessible for old people and children. This directly increases the waiting and crossing times, while increasing the risk. The effect of geometrics of roadside facilities should also be considered.
5) In India, most of the crashes tend to occur at un-signalized intersections rather than signalized intersections. In this context, precedence should be given to studies at unsignalised intersections.
6) Impact of Non-motorised vehicles should be considered.
7) Effect of using mobile phones and electronic gadgets , which is getting predominant, in recent times is envisaged to be a major contributing factor towards increasing risks.

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